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Susceptibilities of 45 Clinical Isolates of *Proteus penneri*

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Patterns of susceptibility of 45 *Proteus penneri* clinical isolates to 14 antimicrobial agents were evaluated by a macrobroth dilution method. All strains were highly susceptible to ceftizoxime, ceftazidime, moxalactam, cefoxitin, gentamicin, tobramycin, netilmicin, and, with few exceptions, to amikacin, piperacillin, and cefoperazone. Most strains were susceptible to cefotaxime and ceftriaxone. All strains were resistant to cefazolin and cefsulodin.

Proteus penneri has been recently recognized as a new member of the tribe *Proteeae* (4, 12). Previously, it had been classified as indole-negative *P. vulgaris* biogroup 1. *P. penneri* is indole, esculin, and salicin negative after 48 h of incubation and exhibits a narrow zone of inhibition around a 30-μg chloramphenicol disk (usually <14 mm). These characteristics are essential in differentiating *P. penneri* from *P. vulgaris* biogroup 2 (indole, salicin, and esculin positive, chloramphenicol susceptible) and from *P. vulgaris* biogroup 3 (indole positive, salicin and esculin negative). The chloramphenicol resistance pattern of the latter biogroup has not yet been satisfactorily delineated (4).

P. penneri has been isolated from urine, blood, stools, abdominal wounds, and bronchial exudates (4); however, its natural habitat is unknown, and its etiological role in infectious processes has not been fully established. One recent report implicated *P. penneri* in a urinary tract infection with bladder calculi formation (10).

A total of 45 clinical isolates of *P. penneri* were included in the study. Forty isolates, including the type strain ATCC 33519, were supplied by the University of Toronto, Toronto Ontario, Canada (courtesy of J. L. Penner), and five strains were isolated from patients at St. Joseph's Health Center, Toronto, Ontario, Canada. Isolates were identified by standard criteria (4).

MICs of the following antimicrobial agents were determined by the macrobroth dilution method (21): cefazolin (Smith Kline & French Canada, Inc.), cefotaxime (Roussel Canada, Inc.), cefoxitin (Charles Frosst & Co., Canada), ceftazidime (Glaxo Canada, Ltd.), ceftizoxime (Smith Kline & French Canada, Inc.), ceftriaxone (Hoffmann-La Roche, Ltd.), cefoperazone (Pfizer Canada, Inc.), cefsulodin (Ciba-Geigy Canada, Inc.), moxalactam (Eli Lilly & Co. of Canada), piperacillin (Cyanamid Canada, Inc.), gentamicin (Schering Corp.), tobramycin (Eli Lilly & Co. of Canada), netilmicin (Schering Canada, Inc.), and amikacin (Bristol Laboratories of Canada).

The activities of individual antimicrobial agents against clinical isolates of *P. penneri* are shown in Table 1. A total of 90% of isolates were inhibited by (per milliliter) 0.25 μg of ceftizoxime, 0.5 μg of ceftazidime and moxalactam, 1 μg of gentamicin, 2 μg of tobramycin, and 4 μg of netilmicin and cefoxitin. The least active agents against *P. penneri* were cefsulodin and cefazolin, with MICs for 90% of the isolates (MIC_{90}s) of >128 μg/ml. According to the MIC interpretative standards outlined by Washington and Sutter (21), Thornsberry et al. (19), and the drug company information brochures, *P. penneri* strains were 100% susceptible to ceftizoxime, ceftazidime, moxalactam, cefoxitin, gentamicin, tobramycin, and netilmicin, 97.8% susceptible to amikacin, 95.6% susceptible to piperacillin and cefoperazone, 84.4% susceptible to cefotaxime, 64.4% susceptible to ceftriaxone, and 0% susceptible to cefsulodin and cefazolin. Furthermore, in standard disk diffusion tests (2), it was found that 94.9% (37 of 39) of isolates were susceptible to nalidixic acid and 61.5% (24 of 39) of isolates were susceptible to nitrofurantoin.

When our results were compared with those reported by others for *P. vulgaris*, it was evident that there were considerable similarities in susceptibilities to cefazolin (1, 8, 9, 18, 20), moxalactam (1, 5, 7, 11, 14, 16, 20), tobramycin (5, 7), amikacin (5, 15), and ceftazidime (13, 14, 22). *P. penneri* appears to be more resistant to ceftriaxone than does *P. vulgaris* with MIC_{90}s of 64 and 0.12 to 12.5 μg/ml, respectively (1, 13, 17, 22). Whereas *P. penneri* was generally resistant to cefoperazone (MIC_{90}, 32 μg/ml), *P. vulgaris* strains have been reported to have MIC_{90}s as low as 1 μg/ml and as high as 100 μg/ml (1, 5, 6, 13, 14, 18). There appears to be a marked susceptibility of *P. penneri* to ceftizoxime (MIC_{90}, 0.25 μg/ml), in contrast to *P. vulgaris* (MIC_{90}s, 2 and 12.5 μg/ml [references 13 and 17, respectively]). Cefoxitin was only slightly more active against *P. penneri* (MIC_{90}, 4 μg/ml) than against *P. vulgaris* (MIC_{90}s, 6.25, 8, 16, 32, and 50 μg/ml [references 1, 5, 9, 13, and 18, respectively]). In a recent report, *P. penneri* strains were reported to be more

TABLE 1. Comparative MICs (micrograms per milliliter) of 14 antimicrobial agents against 45 strains of *P. penneri*

Antibiotic	MIC range	Modal MIC	MIC_{50}[a]	MIC_{90}
Cefotaxime	≤0.12–≥32	1	1	>16
Cefoperazone	≤1–128	1	2	32
Ceftriaxone	0.12–>128	0.5	1	64
Ceftazidime	0.06–2	0.12	0.12	0.5
Cefazolin	≥128	>128	>128	>128
Cefoxitin	1–8	4	2	4
Cefsulodin	≤64–>128	128	128	>128
Ceftizoxime	≤0.03–2	≤0.03	0.03	0.25
Moxalactam	≤0.25–2	≤0.25	0.25	0.5
Piperacillin	≤1–≥128	≤1	2	16
Gentamicin	0.5–4	1	0.5	1
Tobramycin	0.25–8	2	1	2
Netilmicin	0.5–8	2	2	4
Amikacin	1–32	8	4	8

[a] MIC_{50}, MIC at which 50% of the isolates were inhibited.

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resistant to the newer semisynthetic ureidopenicillins, azlocillin and mezlocillin (3). However, in our study, *P. penneri* strains were generally found to be susceptible to piperacillin (MIC_{90}, 16 μg/ml). Although the patterns of susceptibility to these three ureidopenicillins, ceftizoxime, and ceftriaxone suggest a basis for differentiating *P. penneri* from *P. vulgaris*, more isolates need to be studied.

The overall evaluation of the in vitro activity of ceftizoxime, ceftazidime, moxalactam, and cefoxitin suggests that these agents may prove to be clinically useful in treating infections caused by *P. penneri*. All four aminoglycosides tested were extremely active against *P. penneri* and should therefore be considered as drugs of choice for the treatment of systemic infections caused by susceptible *P. penneri* strains.

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